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(54) IMAGE PROCESSING METHOD AND DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an image processing method and device that uses an upsilon filter so as to properly extract borders of illuminations even when a plurality of the different illuminations exist and suppresses production of an unnatural image pattern thereby realizing subjectively preferable compression of the dynamic range.
SOLUTION: The image processing method and device calculates the edge strength G (x, y) for each position on an input image, and a threshold E (x, y) of the upsilon filter 12 is controlled on the basis of the edge strength G (x, y). The upsilon filter 12 applies filter processing to the input image on the basis of the controlled threshold E (x, y). Since the threshold E of the upsilon filter 12 is adaptively changed in response to a local gradient of a pixel I (x, y), the image processing method and device can more accurately extract the illuminance borders than in the case with using a linear low-pass filter or an upsilon filter whose threshold is fixed.

CLAIMS

[Claim(s)]

[Claim 1]An image processing method characterized by comprising the following for changing an inputted picture into a picture with a dynamic range small relative more.
An edge intensity calculating process which computes edge intensity for every position on an inputted image.
A threshold control process which controls a threshold of an epsilon delta technique filter based on said computed edge intensity.
A filtering process in which filtering with said epsilon delta technique filter is performed to said inputted image using a threshold controlled in said threshold control process.
A pixel value conversion process which computes a coefficient for changing a pixel value according to an output value of said filtering process, and changes a pixel value for every pixel with the computed coefficient.

[Claim 2]The image processing method according to claim 1 computing such a big value as said edge intensity that a primary differential value of a pixel value in a neighborhood field of a noticed picture element is large in said edge intensity calculating process.
[Claim 3]The image processing method according to claim 1 controlling said threshold by said threshold control process so that said edge intensity is large, and said threshold becomes small.
[Claim 4]The image processing method according to claim 1 controlling said threshold by said threshold control process so that said threshold becomes large so that a pixel value of said inputted image is large, and said edge intensity is large and said threshold becomes small.

[Claim 5]The image processing method according to claim 1, wherein it computes two thresholds from which a size differs in said threshold control process and a value of a neighborhood picture element uses a threshold in which a case where it is large differs from a case where it is small, compared with a noticed picture element in said filtering process.

[Claim 6]In said filtering process, when a value of a neighborhood picture element is larger than a value of a noticed picture element, The image processing method according to claim 5 characterized by using a threshold with a smaller value when a value of a neighborhood picture element is smaller than a value of a noticed picture element using a threshold with a larger value between said two thresholds.

[Claim 7]The image processing method according to claim 1 performing filtering with said epsilon delta technique filter to an inputted image after having a process in which nonlinear conversion is performed in a pixel level of said inputted image and performing the nonlinear conversion to it.

[Claim 8]The image processing method according to claim 7, wherein said nonlinear transformation is logarithmic transformation.

[Claim 9]An image processing device characterized by comprising the following for changing an inputted picture into a picture with a dynamic range small relative more.

An edge intensity calculating means which computes edge intensity for every position on an inputted image.

An epsilon delta technique filter which performs filtering to said inputted image using a set-up threshold.

A threshold control means which controls a threshold used with said epsilon delta technique filter based on said edge intensity computed by said edge intensity calculating means.

A pixel value conversion method which computes a coefficient for changing a pixel value according to an output value from said epsilon delta technique filter, and changes a pixel value for every pixel with the computed coefficient.

[Claim 10]The image processing device according to claim 9, wherein said edge intensity calculating means is constituted so that such a big value as said edge intensity that a primary differential value of a pixel value in a neighborhood field of a noticed picture element is large may be computed.

[Claim 11]The image processing device according to claim 9, wherein said threshold control means controls said threshold so that said edge intensity is large, and said threshold becomes small.

[Claim 12]The image processing device according to claim 9, wherein said threshold control means controls said threshold so that said threshold becomes large so that a pixel value of said inputted image is large, and said edge intensity is large and said threshold becomes small.

[Claim 13]The image processing device according to claim 9, wherein said threshold control means computes two thresholds from which a size differs, and said epsilon delta technique filter is constituted so that a value of a neighborhood picture element may use a threshold in which a case where it is large differs from a case where it is small, compared with a noticed picture element.
[Claim 14]When a value of a neighborhood picture element is larger than a value of a noticed picture element, said epsilon delta technique filter, The image processing device according to claim 13 constituting using a threshold with a larger value between said two thresholds so that a threshold with a smaller value may be used, when a value of a neighborhood picture element is smaller than a value of a noticed picture element.
[Claim 15]The image processing device according to claim 9, wherein it has a means to perform nonlinear conversion to a pixel level of said inputted image, and said epsilon delta technique filter is constituted so that said filtering may be performed to an inputted image after said nonlinear conversion was performed.
[Claim 16]The image processing device according to claim 15, wherein a means to perform said nonlinear conversion is what log transforms to a pixel level of said inputted image.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention is suitably [for the input/output device of various kinds of pictures, such as television, a videotape recorder, a still camera, a video camera and a printer,] available.
It is related with the image processing method and device for reproducing the picture inputted especially in an image device with a dynamic range narrow relative more.

[0002]
[Description of the Prior Art]There is the method (it is hereafter described as "level conversion".) of changing with a function (it is hereafter described as a "level conversion function".) with input/output relation as shows the level as the solid line of drawing 18 to each pixel of an inputted image for conversion of the gradation characteristic of the former, for example, a picture. In drawing 18, a horizontal axis expresses pixel level [of the outputted image according / a vertical axis / pixel level (input level) l of an inputted image to level conversion processing] (output level) T (l). Lmax expresses the maximum level which each pixel of an input-and-output picture can take. The contrast of the picture after level conversion will increase, so that inclination

of a level conversion function is large. In the example of drawing 18, inclination of the straight line which shows a low level conversion function bordering on the input level ls the high-level side bordering on input level lb is small compared with inclination of an intermediate level (input level ls-lb). Therefore, the contrast of the intermediate level is made increased by sacrificing contrast in a high level and a low in the level conversion using the function shown in drawing 18.

[0003]What [not only] was shown in drawing 18 but the thing shown, for example as the solid line of drawing 19 can also be used for a level conversion function. Inclination of the straight line [function / which was shown in drawing 19 / level conversion] by the side of a high level bordering on the input level lk is small compared with inclination by the low and an intermediate level. Therefore, the contrast in a low and an intermediate level can be made to increase by sacrificing contrast in a high level in the level conversion using the function shown in drawing 19. A more nearly continuous level conversion function may be used compared with functions shown in drawing 18 and drawing 19, such as a gamma function of the following (1) types, and a LOG function of (2) types. g in (1) type is a parameter which adjusts inclination of a function.

[0004]

[Equation 1]

$$T(l) = \left(\frac{l}{Lmax}\right)^{g} \times Lmax \quad \cdots (1)$$

[0005]

[Equation 2]

$$T(l) = \frac{log(l)}{log(Lmax)} \times Lmax \quad \cdots (2)$$

[0006]As another conventional example, there is a method of changing a level conversion function accommodative according to the frequency distribution of the pixel level of an inputted image, and the method called histogram IKORAIZESHON as the example of representation is mentioned. The principle of this histogram IKORAIZESHON is shown in drawing 20 (A) and (B). In drawing 20 (A), a horizontal axis expresses pixel level (input level) l of an inputted image, and a vertical axis expresses frequency (frequency or accumulation frequency). Fmax is the maximum of accumulation frequency.

It is a total of a pixel used in order to compute frequency.

In this method, as shown in drawing 20 (A), the frequency distribution H (l) about pixel level l of an inputted image is generated first, and then the accumulation frequency distribution C (l) is generated using the following (3) types.

[0007]

[Equation 3]

$$C(l) = \sum_{k=0}^{l} H(k) \quad \cdot \cdot \cdot (3)$$

[0008]The level conversion function T (l) is generated by normalizing the vertical axis of this accumulation frequency distribution C (l) to the level range which an outputted image can take using the following (4) types (drawing 20 (B)). By using this function T (l), it becomes possible to make the contrast of the field (field where area is large) constituted by a level with the high frequency of occurrence increase.

[0009]

[Equation 4]

$$T(l) = \frac{C(l)}{Fmax} \times Lmax \quad \cdot \cdot \cdot (4)$$

[0010]When using in the environment whose dynamic range is smaller in the inputted picture namely, which has little number of bits expressing a pixel level (when transmitting in a transmission line with little number of bits) When displaying on a display, or to save at memory storage, it is necessary to compress a dynamic range. Conventionally, the same level conversion as the method mentioned above is used also for compression processing of the dynamic range in such a purpose. However, the maximum level of the outputted image of a level conversion function serves as a value smaller than that of an inputted image in this case.

[0011]On the other hand, Literature "Z. Rahman, et, alt.:"A Multiscale retinex for color rendition and dynamic range compression in Applications of Digital In image Processing" and XIX Proc. SPIE 2847 (1996)." A low pass filter extracts the ingredient of the illumination light which changes gently spatially, and the method of compressing an overall dynamic range by compressing this is proposed (this method is hereafter described as the "Multiscale retinex method".). The narrow linearity low pass filter of the zone is used for extraction of a lighting ingredient. by this method, it is shown in the following (5) types -- as -- the value I of an input pixel (x, y), and the logarithm of low pass filter output LPF (I (x, y)) -- a value is taken and compression of a dynamic range is performed by deducting the latter from the former.

[0012]

[Equation 5]

$$O(x, y) = \log(I(x, y)) - \log(LPF(I(x, y))) \quad \cdot \cdot \cdot (5)$$

[0013]

[Problem(s) to be Solved by the Invention]By the way, in the conventional level conversion method mentioned above, in order to avoid that an unnatural picture is generated, the level conversion function which has monotonicity is used. For this reason, when the contrast (inclination of a level conversion function) of one of level ranges is

made to increase, there is a problem that contrast will fall conversely, in other level ranges.

[0014]Although it makes it possible to reproduce a picture with higher contrast by sacrificing monotonicity in the Multiscale retinex method, When lighting conditions change rapidly, in a linear filter, the change cannot be extracted but there is a problem that the noise which is not preferred will occur subjectively.

[0015]For example, if a linearity low pass filter is given to the picture (the inside of a figure, solid line) which two fields where lighting conditions differ adjoin as shown in drawing 21, the signal with which the boundary faded as the thin dashed line showed will be acquired as a filter output among a figure. When it is considered that this is a lighting ingredient, in the field on the left-hand side of a lighting boundary (area B), an illumination level will be lower than the portion (BFB field) which separated near the boundary (BNB field) from the boundary. Since it means being compressed so greatly that above-mentioned (5) types being equivalent to carrying out division process of the input signal of a lighting ingredient and a lighting ingredient being large, in the BNB field of a reappearance picture (the inside of a figure, thick dashed line), overshooting occurs as a result. On the contrary, in the field on the right-hand side of a lighting boundary (D region), it is considered that near a boundary (DNB field) has a high illumination level compared with the portion (DFB) separated from the boundary, and undershoot occurs. By the Multiscale retinex method, in order to avoid this problem, use the method of compounding the result obtained by each low pass filter according to linearity load using several linearity low pass filters from which a scale differs, but. It is being fixed and the dignity to each scale has not fully controlled the above-mentioned problem.

[0016]Then, it is possible to extraction of a lighting ingredient not a linearity low pass filter but to use nonlinear filters, such as an epsilon delta technique filter, for example. Also in the picture in which it excels in the capability to save edge compared with a linear filter, and different illumination light exists, the epsilon delta technique filter can extract a lighting ingredient more effectively. However, in the epsilon delta technique filter of threshold immobilization generally used for the purpose of noise rejection etc. Since a discontinuous waveform is formed in the output [near the edge], when this is used for compression of a dynamic range, it may be generated in the reappearance picture after compression by the unnatural image pattern which is not in an original image.

[0017]This invention was made in view of this problem, and the purpose, Also when several different lighting exists using an epsilon delta technique filter, it is in making it possible to extract those boundaries appropriately, suppressing generating of an unnatural image pattern, and providing the image processing method and device which can realize compression of a desirable dynamic range subjectively.

[0018]

[Means for Solving the Problem]An edge intensity calculating process in which an image processing method by this invention computes edge intensity for every position on an inputted image, A threshold control process which controls a threshold of an epsilon delta technique filter based on computed edge intensity, A filtering process in which filtering with an epsilon delta technique filter is performed to an inputted image using a threshold controlled in a threshold control process, A coefficient for changing a pixel value is computed according to an output value of a filtering process, and a pixel value conversion process which changes a pixel value for every pixel is included with the computed coefficient.

[0019]An image processing device of this invention is characterized by comprising:

An edge intensity calculating means which computes edge intensity for every position on an inputted image.

An epsilon delta technique filter which performs filtering to an inputted image using a set-up threshold.

A threshold control means which controls a threshold used with an epsilon delta technique filter based on edge intensity computed by edge intensity calculating means.

A pixel value conversion method which computes a coefficient for changing a pixel value according to an output value from an epsilon delta technique filter, and changes a pixel value for every pixel with the computed coefficient.

[0020]Edge intensity is computed for every position on an inputted image, and a threshold used with an epsilon delta technique filter is controlled by an image processing method and a device by this invention based on the computed edge intensity. And a coefficient for changing a pixel value is computed according to an output value from an epsilon delta technique filter, and conversion of a pixel value is performed by the computed coefficient for every pixel. Also when several different lighting exists by this, in filtering with an epsilon delta technique filter, it is supposed that it is possible to extract those boundaries appropriately.

[0021]In this invention, a threshold of an epsilon delta technique filter is controlled, for example so that edge intensity is large, and a value becomes small. At this time, it may control to enlarge a threshold, so that a pixel value of an inputted image is still larger. Thereby, in filtering with an epsilon delta technique filter, influence of an illumination level in change of a pixel value is reduced, and extraction of a lighting ingredient is made more appropriately.

[0022]Two thresholds from which a size differs are computed and it may be made to control a threshold. At this time, a value of a neighborhood picture element performs filtering with an epsilon delta technique filter using a threshold in which a case where it is large differs from a case where it is small, compared with a noticed picture element, for example. In filtering, influence of an illumination level in change of a pixel value is reduced by this, and extraction of a lighting ingredient is more appropriately made.

[0023]

[Embodiment of the Invention]Hereafter, an embodiment of the invention is described in detail with reference to drawings.

[0024][A 1st embodiment] Intermediary explanation is given at the input picture signal first processed in the image processing device concerning this embodiment. The input picture signal processed in this image processing device is a signal of the time series pixel value acquired by scanning in order of horizontal and a perpendicular direction in the two-dimensional digital image as shown in drawing 2. The pixel value corresponding to the arbitrary positions (x, y) on a two-dimensional picture is expressed in this embodiment as I (x, y), and this is processed as an input picture signal.

[0025]Next, the composition of the image processing device concerning this embodiment is explained. This image processing device is provided with the following.

As shown in drawing 1, it is the edge intensity calculation machine 10.

Threshold controller 11.

Epsilon delta technique filter 12.

The divider 13, the level converter 14, and the multiplier 15.

[0026]The edge intensity calculation machine 10 has a function which computes edge intensity G (x, y) of the pixel value I (x, y) in each position of an inputted image. As edge intensity G (x, y), the primary differential value of I (x, y) which is given, for example by the following (6) formulas can be used.

[0027]

[Equation 6]

$$G(x, y) = |I(x-d, y)-I(x+d, y)| + |I(x, y-d)-I(x, y+d)| \quad \cdots (6)$$

[0028]Or in order to suppress the influence of a noise, it is also possible to use the value by (7) types of the following with a flattening effect as edge intensity G (x, y).

[0029]

[Equation 7]

$$G(x, y) = \left|\sum_{dy=-d}^{d} [I(x-d, y+dy)-I(x+d, y+dy)]\right| + \left|\sum_{dx=-d}^{d} [I(x+dx, y-d)-I(x+dx, y+d)]\right| \quad \cdots (7)$$

[0030]Here, in (6) and (7) types, d is a constant which shows the minute distance for computing differentiation. Edge intensity G (x, y) computed in the edge intensity calculation machine 10 is sent to the threshold controller 11.

[0031]The threshold controller 11 has the function to determine the size of threshold E (x, y) used with the below-mentioned epsilon delta technique filter 12 for every pixel, based on edge intensity G (x, y) computed with the edge intensity calculation machine

10. It is controlled so that threshold E (x, y) becomes such a small value that edge intensity G (x, y) is large by using the following (8) types, for example with the function of the threshold controller 11.

[0032]

[Equation 8]

$$E(x,y)=\begin{cases} Emin & \cdots G(x,y)>Gmax \\ \dfrac{Gmax-G(x,y)}{Gmax-Gmin}(Emax-Emin)+Emin & \cdots Gmin\leqq G(x,y)\leqq Gmax \\ Emax & \cdots G(x,y)<Gmin \end{cases} \quad \cdot\cdot\cdot (8)$$

[0033](8) In a formula, Gmin, Gmax, Emin, and Emax are the constants for changing edge intensity G (x, y) into threshold E (x, y), and express the minimum of edge intensity, the maximum, the minimum of threshold E (x, y), and the maximum, respectively. Threshold E (x, y) determined in the threshold controller 11 is sent to the epsilon delta technique filter 12.

[0034]the epsilon delta technique filter 12 was shown in drawing 4 -- as -- for example, difference -- it has the vessel 20, the absolute value calculation machine 21, the comparator 22, and the linearity low pass filter (by a diagram, it is described as LPF.) 23, and is constituted. This epsilon delta technique filter 12 is a two-dimensional filter, and has the function to perform nonlinear filtering to an inputted image, using threshold E (x, y) determined by the threshold controller 11. The output R of the epsilon delta technique filter 12 (x, y) is sent to the divider 13 and the level converter 14 as a lighting ingredient.

[0035]In order to remove a lighting ingredient computed with the epsilon delta technique filter 12 from an inputted image, the divider 13 carries out division process of each pixel value I of an inputted image (x, y) of the lighting ingredient R (x, y), as shown in the following (9) types. The non-illuminating ingredient S (x, y) obtained as a result of carrying out division process is sent to the multiplier 15.

[0036]

[Equation 9]

$$S(x,y)=\frac{I(x,y)}{R(x,y)} \quad \cdot\cdot\cdot (9)$$

[0037]The level converter 14 is compressed by carrying out level conversion of the lighting ingredient R (x, y) computed with the epsilon delta technique filter 12 by the level conversion function T (l), as shown in the following (10) types, and it has a function which computes amendment lighting ingredient CR (x, y).

[0038]

[Equation 10]

$$CR(x,y)=T(R(x,y)) \quad \cdot\cdot\cdot (10)$$

[0039]As level conversion function T (l) used by the level converter 14, a function as shown, for example in drawing 3 can be used. In drawing 3, Rmax and CRmax express the maximum of the input level and the output level, respectively.
[0040]The multiplier 15 restores a picture signal to the non-illuminating ingredient S (x, y) in integrating amendment lighting ingredient CR (x, y), as shown in the following (11) types. The picture signal O (x, y) which shows a restored result is outputted to a transmission line, memory storage, or a display etc. which is not illustrated.
[0041]
[Equation 11]
$$O(x, y) = S(x, y)CR(x, y) \quad \cdots (11)$$

[0042]In this embodiment, the divider 13, the level converter 14, and the multiplier 15 correspond to one example of the "pixel value conversion method" in this invention.
[0043]Next, an operation of the image processing device constituted as mentioned above and operation are explained. The following explanation serves as explanation of the image processing method concerning this embodiment.
[0044]The signal which shows an inputted image is inputted into the edge intensity calculation machine 10, the epsilon delta technique filter 12, and the multiplier 13 in this image processing device. First, in the edge intensity calculation machine 10, the size of edge, i.e., edge intensity G, (x, y) is computed for every position of an inputted image. At this time, the edge intensity calculation machine 10 computes edge intensity G (x, y) by [as it serves as such a big value that the primary differential value of the pixel value in the neighborhood field of a noticed picture element is large] by using above-mentioned (6) types or (7) types, for example. The edge intensity calculation machine 10 outputs computed edge intensity G (x, y) to the threshold controller 11.
[0045]Based on edge intensity G (x, y), threshold E of the epsilon delta technique filter 12 is controlled by the threshold controller 11. In more detail, for example using above-mentioned (8) types, the threshold controller 11 determines a size of threshold E (x, y) for every pixel, and it controls it so that edge intensity G (x, y) is large, and threshold E (x, y) becomes small. The threshold controller 11 outputs determined threshold E (x, y) to the epsilon delta technique filter 12.
[0046]In the epsilon delta technique filter 12, filtering is performed to an inputted image using threshold E (x, y) determined by the threshold controller 11.
[0047]Filtering in the epsilon delta technique filter 12 is performed as follows in more detail by composition shown, for example in drawing 4. in the epsilon delta technique filter 12 -- difference -- as shown in drawing 4, a signal which shows the value I of the present noticed picture element (x, y), and a signal which shows the value I of a pixel in the neighborhood field NB (x+dx, y+dy) are inputted into the vessel 20. difference -- in the vessel 20, difference of the value I of a noticed picture element (x, y) and the value I

of a pixel in the neighborhood field NB (x+dx, y+dy) is computed. difference -- in the vessel 20, this difference value will be calculated one by one to all the pixels in the field NB soon, it matches with each neighborhood picture element, and that value D (dx, dy) is outputted to the absolute value calculation machine 21.

[0048]the absolute value calculation machine 21 -- difference -- absolute value AD (dx, dy) of each difference value D (dx, dy) sent from the vessel 20 is computed. In the absolute value calculation machine 21, computed absolute value AD (dx, dy) is outputted to the comparator 22.

[0049]Absolute value AD (dx, dy) computed with the absolute value calculation machine 21 is inputted into the comparator 22, and. A signal which shows the value I (x+dx, y+dy) of a pixel in a signal which shows the value I of a noticed picture element (x, y), and its neighborhood field NB, and threshold E (x, y) determined with the threshold controller 11 are inputted. The comparator 22 compares absolute value AD (dx, dy) and threshold E (x, y), as shown in the following (12) types, According to the result, either one of the value I of a noticed picture element (x, y) or the value I of a neighborhood picture element (x+dx, y+dy) is chosen, and it is outputted to the linearity low pass filter 23 as the value J (dx, dy).

[0050]

[Equation 12]

$$J(dx, dy) = \begin{cases} I(x, y) & \cdots AD(dx, dy) > E(x, y) \\ I(x+dx, y+dy) & \cdots AD(dx, dy) \leq E(x, y) \end{cases} \quad \cdots (12)$$

[0051]In the linearity low pass filter 23, when the value J corresponding to all the pixels in the field NB (dx, dy) will be computed by the comparator 22 soon, the weighted average efficiency R by the following (13) types (x, y) is computed.

[0052]

[Equation 13]

$$R(x, y) = \sum_{(dx, dy) \in NB} a(dx, dy) J(dx, dy) \quad \cdots (13)$$

[0053]Here, NB is a set of relative coordinates which defines the neighborhood field in filtering processing. a (dx, dy) is a weighting factor to each pixel value, and can use a mean value filter as shown, for example in the following (14) types etc. as this linearity low pass filter 23.

[0054]

[Equation 14]

$$R(x, y) = \frac{1}{N} \sum_{(dx, dy) \in NB} J(dx, dy) \quad \cdots (14)$$

[0055](14) In the formula, N expresses the number of the pixels in [NB] a field soon. It is the purpose of the epsilon delta technique filter 12 removing a fine structure in a

picture, and extracting the collected field, and the larger one of the neighborhood field is desirable.

[0056]It is thought that the value R (x, y) obtained with the epsilon delta technique filter 12 as mentioned above expresses a lighting ingredient approximately contained in a picture. The epsilon delta technique filter 12 is outputted to the divider 13 and the level converter 14 by using the value R (x, y) as a lighting ingredient.

[0057]In the divider 13, as shown in above-mentioned (9) types, by doing division of each pixel value I of an inputted image (x, y) of the lighting ingredient R (x, y), a lighting ingredient computed with the epsilon delta technique filter 12 is removed from an inputted image, and the non-illuminating ingredient S (x, y) obtained as a result is outputted to the multiplier 15.

[0058]On the other hand, in the level converter 14, it compresses by carrying out level conversion by the level conversion function T (l) as shows drawing 3 the lighting ingredient R (x, y) computed with the epsilon delta technique filter 12, for example, and amendment lighting ingredient CR (x, y) is computed. The level converter 14 outputs computed amendment lighting ingredient CR (x, y) to the multiplier 15.

[0059]In the multiplier 15, integrating amendment lighting ingredient CR (x, y) which is an output from the level converter 14 restores a picture signal to the non-illuminating ingredient S (x, y) which is an output from the divider 13. If an operation of the above divider 13, the level converter 14, and the whole multiplier 15 is considered, here integrating amendment lighting ingredient CR (x, y) for the non-illuminating ingredient S (x, y), In computing the coefficient F (R (x, y)) for changing a pixel value according to the output value R from the epsilon delta technique filter 12 (x, y), and integrating it to the corresponding input pixel value I (x, y), as shown in (16) types mentioned later. It is equivalent to changing a pixel value for every pixel and compressing a dynamic range.

[0060]The picture signal O (x, y) outputted from the multiplier 15 as mentioned above. In little environment (in a case where it transmits in a transmission line with little number of bits, when [when displaying on a display, or when saving at memory storage], etc.), the number of bits which expresses relatively a narrow image device of a dynamic range, i.e., a pixel level, is used rather than an inputted image.

[0061]Next, with reference to drawing 5 and drawing 6, validity to a conventional method (when compressing using a level conversion function which has monotonicity) at the time of compressing a dynamic range using the epsilon delta technique filter 12 in this embodiment is explained.

[0062]Drawing 5 (A) is the figure which expressed the output R (x, y) from the epsilon delta technique filter 12 in the pixel value I (x, y) and this embodiment of an inputted image as a one-dimensional signal. Drawing 5 (B) shows a result (reappearance picture) of having compressed a dynamic range by the conventional level conversion method to an inputted image shown in drawing 5 (A), and drawing 5 (C) shows a result of having compressed a dynamic range in this embodiment.

[0063]Relation between a pixel level of each field, level conversion function T (l), and coefficient enumeration-function F (l) is shown in drawing 6 (A) and (B). Here, it is defined as the coefficient enumeration function F (l) like the following (15) types using the level conversion function T (l).

[0064]

[Equation 15]

$$F(l) = \frac{T(l)}{l} \quad \cdots (15)$$

[0065](11) types which give the outputted image O (x, y) by taking into consideration above-mentioned (9) types and (10) types become possible [rewriting like the following (16) types] using this coefficient enumeration function F (l).

[0066]

[Equation 16]

$$O(x, y) = I(x, y)F(R(x, y)) \quad \cdots (16)$$

[0067]It is shown that this (16) type is realizable in compression of a dynamic range by compression of the lighting ingredient R (x, y) integrating the coefficient F (R (x, y)) computed for every pixel to the corresponding input pixel value I (x, y). At this time, the coefficient enumeration function F (l) has the function to change an output value of the epsilon delta technique filter 12 into a gain factor given to each pixel. The minimum Cmin of a value of coefficient enumeration-function F (l) in drawing 6 (B) will be given by the following (17) formulas.

[0068]

[Equation 17]

$$Cmin = \frac{CRmax}{Rmax} \quad \cdots (17)$$

[0069]The conventional method can save the contrast in a low field (field which comprises the level l1 shown in drawing 5 (A), and the level l3) so that drawing 5 (B) may also show, but. The fall of contrast is caused in the high-level field (field which comprises the level l4 and the level l6). This is the result of receiving directly the influence of inclination of level conversion function T (l) to the high level more than the point of inflection lk. In order to raise contrast in a conventional method, it is necessary to enlarge inclination of level conversion function T (l).

[0070]On the other hand, in this embodiment (drawing 5 (C)), since a single correction factor given by the coefficient enumeration function F (l) is given to each of a high-level field and a low field, it will depend for contrast in each field on a size of this correction factor. Although a correction factor decided by the average level l2 is uniformly given to a low field in this embodiment, the value is the 1.0 [same] as a

thing to the level l1 and the level l3, and contrast comparable as a conventional method is acquired. Since the fixed correction factor c5 decided by that average value l5 is given to a high-level field, contrast between a portion of the level l4 and a portion of the level l6 will be secured by this gain.

[0071]The level conversion function T (l) which consists of two straight lines from which inclination as shown in drawing 6 (A) actually differs is used, When a straight line corresponding to more than the turning point level lk is expressed with the following (18) types, contrast of a high-level field in a conventional method is given by "a (l6-l4)/l5" depending on the slope-of-a-line a. However, a "/(maximum level minimum level) average level" defines contrast here.

[0072]

[Equation 18]

$$T(l) = al+b \quad \cdots \quad l \geq lk \quad \cdots (18)$$

[0073]On the other hand, the correction factor c5 applied to a high-level field in this embodiment is given by the following (19) formulas.

[0074]

[Equation 19]

$$c5 = \frac{a \times l5 + b}{l5} = a + \frac{b}{l5} \quad \cdots (19)$$

[0075]Therefore, although the contrast of this field becomes c5 (l6-l4) / l=[5] {a (l6-l4)/l5}+ {b/(l5*l5)} in this embodiment, Since it is usually smaller than 1.0, as for the section b, the inclination in a high level of level conversion function T (l) in compression of a dynamic range always takes a positive value. This shows that contrast with a higher method by this embodiment using the epsilon delta technique filter 12 is realizable compared with the conventional method.

[0076]Thus, contrast in a field extracted with the epsilon delta technique filter 12 in this embodiment, It will be decided by the value of a correction factor given by the coefficient enumeration function F (l) itself, and inclination of level conversion function T (l) will affect contrast between fields. Therefore, according to this embodiment, by compressing contrast between fields, contrast in a field can be saved and a desirable outputted image can be obtained subjectively.

[0077]Next, an effect of this embodiment to a conventional method using a linearity low pass filter is explained. However, in order to explain simply, a picture is expressed as a one-dimensional signal here. Although the problem of a conventional method is as having already explained using drawing 21 in the item of [Problem(s) to be Solved by the Invention], it is necessary to smooth the inside of the field under the same lighting, saving the boundary (lighting boundary) of the field where lighting conditions differ, in order to solve the problem. By the way, as for change of the pixel level resulting from

change of illumination intensity, edge with a big pixel level will occur on a lighting boundary far more greatly on experience than change of the pixel level resulting from the reflectance of an object surface as a result.

[0078]As shown in drawing 7 (A), the pixel value I (x+dx, y+dy) which gives big difference absolute value AD (dx, dy) exceeding threshold E (x, y) into the neighborhood field NB of a noticed picture element of the epsilon delta technique filter 12 will exist around such edge. Since this pixel value I (x+dx, y+dy) is transposed to the value (value of a center of neighborhood field NB) (x, y) I of the present noticed picture element by the comparator 22 (drawing 4) as a thick dashed line (I' (dx, dy)) of drawing 7 (A) shows, (13) It will not contribute to smoothing by a formula greatly, but shape of edge will be saved as a result. On the other hand, in portions other than a lighting boundary, as shown in drawing 7 (B), change of a pixel level will not become so big, but difference absolute value AD (dx, dy) will become smaller than threshold E (x, y) over the whole neighborhood field NB of a noticed picture element. In this case, all J (dx, dy) of (12) types is equal to the input pixel value I (x+dx, y+dy), an epsilon delta technique filter becomes equivalent to a simple linearity low pass filter, and smoothing over the whole field NB will be performed soon.

[0079]Thus, the epsilon delta technique filter 12 can extract a lighting ingredient more effectively also in a picture in which it excels in capability to save edge compared with a linear filter, and different illumination light exists. However, in the conventional epsilon delta technique filter of threshold immobilization generally used for the purpose of noise rejection etc. Since a discontinuous waveform is formed in the output [near the edge], when this is used for compression of a dynamic range, it may be generated in a reappearance picture after compression by unnatural image pattern which is not in an original image.

[0080]In order to explain this problem, an output of modeled edge and the conventional epsilon delta technique filter of threshold immobilization in the circumference of it is shown in drawing 8 (A) and (B). Here, only the high-level side is considered from an edge center section, an edge part from which a level changes rapidly is a straight line of the inclination a, and the other edge peripheral part is approximated in a flat straight line of the inclination 0. The thick dashed line 83 shows an output of a linearity low pass filter which corresponds an input signal as the thin solid line 81, and corresponds an output of an epsilon delta technique filter as the thick solid line 82 by drawing 8 (A) and (B). Neighborhood area size of a noticed picture element in an epsilon delta technique filter to be used is set to N, and the threshold is set to E. Drawing 8 (A) is an output of an epsilon delta technique filter in case a relation of the following (20) types is materialized between a, N, and E.

[0081]

[Equation 20]

$$N < \frac{2E}{a} \quad \cdots (20)$$

[0082]In drawing 8 (A), a coordinate value shall become large, so that a horizontal axis expresses a spatial position coordinate and it goes to the right. p0 shows the position which separated only N/2 from the falling point pe of edge. In this case, an epsilon delta technique filter is served on a par with a linearity low pass filter. However, the thing for which the level variation on the picture by change of the illumination light is produced steeply (the inclination a is large), Since it is necessary to use a big filter in order to compress an effective dynamic range, as mentioned above (N is large), on the lighting boundary where lighting conditions change, it is usually thought that the conditions of (20) types are not satisfied.

[0083]On the other hand, the output of an epsilon delta technique filter in case (20) types are not materialized is shown in drawing 8 (B). In drawing 8 (B), if the output wave is seen from right-hand side to left-hand side, it will become the output as a linear filter with same p0 to p0-E/a, and pe will output a fixed value after that. Although pe to pe-E/a descends according to a secondary curve, under the conditions on which (20) types are not materialized, the straight line 81 which certainly shows an input signal in the meantime is intersected. In pe-E/a, it becomes the same value as an input signal nonsequetially, and an input signal will be outputted as it is after that. This the behavior of the epsilon delta technique filter of threshold immobilization of output [to the simplified edge model, / although / near edge / a complicated waveform] is clear. In particular, in the hit of pe-E/a, it changes discontinuously and a waveform with bigger inclination than an input signal is outputted.

[0084]In order for the outputted image O (x, y) to turn into a natural reappearance picture, it is necessary to save local shape (direction of a spatial gradient) in each position on a picture. That is, as shown in the following (21) types, numerals of differential value O' (x, y) of the outputted image O (x, y) and numerals of differential value I' (x, y) of the inputted image I (x, y) must be in agreement.

[0085]

[Equation 21]

$$\mathrm{sign}(O'(x, y)) = \mathrm{sign}(I'(x, y)) \quad \cdots (21)$$

[0086]Here, sign(x) expresses the numerals of x. (21) When the conditions of a formula are not fulfilled, the inversion of level inclination will arise between an inputted image and an outputted image, and the image pattern which does not exist in an inputted image will appear in an outputted image. For example, the inputted image shown in drawing 9 (A) is outputted as shown in drawing 9 (B). In the outputted image of drawing 9 (B), the pattern 90 not existing has appeared in the inputted image by the inversion of level inclination. However, discontinuous behavior of the epsilon delta technique filter in

near the edge shown in drawing 8 (B) may make formation of the conditions of this (21) type difficult, and there is a possibility that the inversion of level inclination may arise.
[0087](21) It is dependent on the level conversion function T (l) given to behavior and its output of an epsilon delta technique filter whether a formula is materialized or not. In order to clarify this, (9) types are first substituted for (11) types, and a related (22) formula of the inputted image I (x, y) and the outputted image O (x, y) is obtained.
[0088]
[Equation 22]

$$O(x, y) = I(x, y)\frac{CR(x, y)}{R(x, y)} \quad \cdots (22)$$

[0089](22) CR (x, y)/R (x, y) in the right-hand side of a formula is equivalent to the coefficient enumeration function F (R (x, y)) described previously. (22) The both sides of a formula will be differentiated and the conditions which the outputted image O (x, y) should fulfill by substituting for (21) types will be expressed like the following (23) types.
[0090]
[Equation 23]

$$\begin{cases} \frac{R'(x, y)}{R(x, y)} - \frac{CR'(x, y)}{CR(x, y)} \leq \frac{I'}{I} & \cdots \quad I' \geqq 0 \\ \frac{R'(x, y)}{R(x, y)} - \frac{CR'(x, y)}{CR(x, y)} > \frac{I'}{I} & \cdots \quad I' < 0 \end{cases} \quad \cdots (23)$$

[0091]In order to clarify further the intervention of level conversion function T (l) to this condition, the relation of the output of level conversion function T (l) to the output of an epsilon delta technique filter is shown in drawing 10. A horizontal axis expresses the output (input to level conversion function T (l)) of an epsilon delta technique filter, and the vertical axis expresses the output of level conversion function T (l). Now, the value after R and its level conversion is set to CR for the output of the epsilon delta technique filter of a certain pixel, and value CR/R of these ratios is set to a. That is, a is equivalent to the slope of a line which passes the starting point, and (R, CR) ((24) types).
[0092]
[Equation 24]

$$CR = aR \quad \cdots (24)$$

[0093]If the space differential value of the output of the epsilon delta technique filter in this same pixel is made into R', it will be thought that this is equivalent to the size of the minute range centering on R on the horizontal axis of drawing 10 (however, R has suitable numerals according to the direction of [on the picture which computes a differential value]). Therefore, if the fine coefficient about l of level conversion function T (l) corresponding to R is set to b, the space differential value after level

conversion can be approximated by the following (25) types.
[0094]
[Equation 25]

$$CR' = bR' \quad \cdots (25)$$

[0095](24) By substituting a formula and (25) types for (22) types, the conditions of the partial R'(26) of the following which consists of /R and portion (1-b/a) about character of level conversion function T (l) type about the output of an epsilon delta technique filter can be acquired.
[0096]
[Equation 26]

$$\begin{cases} \dfrac{R'}{R}\left(1-\dfrac{b}{a}\right) \leq \dfrac{I'}{I} & \cdots \quad I' \geq 0 \\ \dfrac{R'}{R}\left(1-\dfrac{b}{a}\right) > \dfrac{I'}{I} & \cdots \quad I' < 0 \end{cases} \quad \cdots (26)$$

[0097]Since the level conversion function T (l) for lighting ingredient compression usually has monotonicity, a and b become a positive value and the following (27) types are materialized.
[0098]
[Equation 27]

$$1-\frac{b}{a} \leq 1 \quad \cdots (27)$$

[0099]Although 1-b/a>=0 means a>=b, it means in this case that such big compression is performed in the neighborhood of the lighting ingredient level R that a level is large. Because, the compression ratio of the level R needs to be a, to compress the neighborhood uniformly, the inclination of level conversion function T (l) in the level R neighborhood needs to be a, but actual inclination is smaller b and will be more greatly compressed by the high-level side to be shown in drawing 11 (A). Conversely, it will be more greatly compressed into the case of 1-b/a, i.e., a<b, by the low side to be shown in drawing 11 (B). The vertical axis and horizontal axis of drawing 11 (A) and (B) express the output (input to level conversion function T (l)) of an epsilon delta technique filter, and the output of level conversion function T (l) like drawing 10, respectively.
[0100]In flat parts other than near edge, since an epsilon delta technique filter functions as a low pass filter, a rate of a spatial change in the output will generally become looser than that of an inputted image. Therefore, in these portions, it can be assumed that two conditions shown in the following (28) types (28A) ((28B)) are satisfied.
[0101]
[Equation 28]

$$\begin{cases} \left|\frac{I'}{I}\right| \geq \left|\frac{R'}{R}\right| & \cdots (28A) \\ sign(I'(x, y)) = sign(R'(x, y)) & \cdots (28B) \end{cases}$$

[0102]Since it is set to R'>=0 from (28) types in the case of I'>=0, if 1-b/a is negative, (26) types will always be materialized. In being 0 <=1-b/a<=1, it becomes like the following (29) types from I'/I>=R'/R obtained from (28) types.

[0103]

[Equation 29]

$$\frac{R'}{R}\left(1-\frac{b}{a}\right) \leq \frac{I'}{I}\left(1-\frac{b}{a}\right) \leq \frac{I'}{I} \quad \cdots (29)$$

[0104]Similarly, it turns out easily that (26) types are materialized also in the case of I'<0.

[0105]On the other hand, since an epsilon delta technique filter will output an input signal as it is in an edge center portion, in this portion, it is thought that the following (30) types are materialized, as shown in drawing 8 (B), but it is clear that (26) types are satisfied also in this case.

[0106]

[Equation 30]

$$\frac{R'(x, y)}{R(x, y)} = \frac{I'(x, y)}{I(x, y)} \quad \cdots (30)$$

[0107]If the epsilon delta technique filter 12 is removed in this embodiment and it is made to be set to R(x, y) =I (x, y), will become equivalent [the result] to the conventional method only by level conversion, but. This will correspond, when the conditions of (30) types are satisfied over the whole picture, and the inversion of level inclination will not occur in a conventional method.

[0108]In the portion by which these conditions are not fulfilled, it is dependent on the output of the epsilon delta technique filter 12, and the characteristic of level conversion function T (l) whether (26) types are materialized. Since the characteristic of level conversion function T (l) is what should be decided by how a lighting ingredient is compressed, in the case of four, it divides into (1) - (4) how the output of the epsilon delta technique filter 12 affects formation of (26) types here, and explains it.

[0109](1) When I'>=0 and R' are the same numerals as 1-b/a; since both the right-hand side and the left side serve as positive, formation of (26) types becomes difficult, so that an absolute value of R'/R is large.

[0110](2) When I'>=0 and R' are different numerals from 1-b/a; since the right-hand side serves as positive and the left side serves as negative, (26) types are always materialized.

[0111](3) When I'<0 and R' are the same numerals as 1-b/a; since the right-hand side serves as negative and the left side serves as positive, (26) types are always materialized.
[0112](4) I' -- < -- since [and] both; right-hand side and the left side serve as negative when R' is different numerals from 1-b/a -- R' -- formation of (26) types becomes difficult, so that /R is large.
[0113]Under the above (2) and conditions of (3), since such little compression that a level of an inputted image is expensive in a field soon will be performed, an inversion of inclination cannot occur. Therefore, no matter R'/R may become what value, (26) types will always be materialized. On the other hand, on condition of (1) and (4), a possibility that (26) will not be filled becomes high so that an absolute value of R'/R is large, but if the ratio is the same as an inputted image at least, it is as having stated above that (26) types are materialized. It is making variable threshold E of the epsilon delta technique filter 12, and outputting the signal possible nearest to an inputted image in an edge part in this embodiment, By namely, a thing for which a threshold is controlled so that edge intensity G (x, y) is large, and threshold E of the epsilon delta technique filter 12 becomes small. It makes it possible to reproduce a natural picture so that an inversion of inclination may be controlled to the minimum and the unnatural pattern 90 as shown in drawing 9 (B) may not arise.
[0114]The level conversion function T (l) shown in drawing 3 is an example to the last, and it cannot be overemphasized that arbitrary things can be used according to the purpose. For example, a function shown in (1) type or (2) types may be used.
[0115]As explained above, according to this embodiment, compute edge intensity G (x, y) for every position on an inputted image, and. Based on this edge intensity G (x, y), control threshold E (x, y) of the epsilon delta technique filter 12, and filtering is performed to an inputted image, By integrating the coefficient F (R (x, y)) computed according to the output value R from the epsilon delta technique filter 12 (x, y) to the input pixel value I (x, y), as shown in (16) types, Since a pixel value is changed for every pixel and it was made to compress a dynamic range, also when several different lighting exists, it makes it possible to extract those boundaries appropriately, generating of an unnatural image pattern is suppressed, and compression of a desirable dynamic range can be realized subjectively. That is, by extracting a lighting ingredient from an inputted image and compressing the lighting ingredient using the epsilon delta technique filter 12, overall dynamic ranges can be reduced with local contrast saved, and a desirable reappearance picture can be acquired subjectively. Since it was made to change threshold E of the epsilon delta technique filter 12 accommodative according to local inclination of the pixel value I (x, y) based on edge intensity G (x, y) at this time, A lighting boundary can be extracted more correctly than a case where an epsilon delta technique filter of a case where a linearity low pass filter is used, or threshold immobilization is used.
[0116][A 2nd embodiment] Next, a 2nd embodiment of this invention is described. In

the following explanation, the same numerals are given to a portion which has the substantially same function as a component in a 1st embodiment of the above, and explanation is omitted suitably.

[0117]Drawing 12 shows composition of an image processing device concerning a 2nd embodiment of this invention. Although an overall function of an image processing device concerning this embodiment is the same as that of a 1st embodiment of the above, in this embodiment, it differs from a 1st embodiment of the above in that the coefficient calculation machine 16 which united and had these functions is installed instead of the divider 13 and the level converter 14 (drawing 1). That is, this embodiment compresses a dynamic range based on (16) types shown by a 1st embodiment of the above.

[0118]In the coefficient calculation machine 16 in this embodiment, a coefficient C (x, y) is computed by giving the coefficient enumeration function F (l) as shown in drawing 13 to the output R of the epsilon delta technique filter 12 (x, y). The coefficient enumeration function F (l) is obtained by (15) types using the level conversion function T (l), as a 1st embodiment of the above described. A coefficient C (x, y) computed with the coefficient calculation machine 16 is sent to the multiplier 15.

[0119]The direct entry of the signal which shows an inputted image is carried out, and a coefficient C (x, y) computed with the calculation machine 16 is inputted into the multiplier 15 in this embodiment. In the multiplier 15, a picture signal is restored in integrating a coefficient C (x, y) corresponding to each pixel value I of an inputted image (x, y), and it outputs to a transmission line, memory storage, or a display etc. which does not illustrate the picture signal O of the result (x, y) like a 1st embodiment of the above.

[0120]Also in this embodiment, based on edge intensity G (x, y), control threshold E (x, y) of the epsilon delta technique filter 12, and filtering is performed to an inputted image, By integrating the coefficient F (R (x, y)) computed according to the output value R from the epsilon delta technique filter 12 (x, y) to the input pixel value I (x, y), Since a pixel value is changed for every pixel and it is made to compress a dynamic range, the same effect as a 1st embodiment of the above can be acquired.

[0121][A 3rd embodiment] Next, a 3rd embodiment of this invention is described. In the following explanation, the same numerals are given to a portion which has the substantially same function as a component in a 1st embodiment of the above, or a 2nd embodiment of the above, and explanation is omitted suitably.

[0122]Drawing 14 shows composition of an image processing device concerning a 3rd embodiment of this invention. Although composition of an image processing device concerning this embodiment is almost the same as a 1st embodiment (drawing 1) of the above, it differs in that the direct entry of the pixel value I (x, y) of an inputted image other than edge intensity G (x, y) which is an output from the edge intensity calculation machine 10 is further carried out to the threshold controller 11.

[0123]Threshold E (x, y) used with the latter epsilon delta technique filter 12 is

controlled by the threshold controller 11A in this embodiment not only with edge intensity G (x, y) but with a pixel level of an inputted image. Threshold E (x, y) becomes large so that the pixel value I of an inputted image (x, y) is large, and more specifically, threshold E (x, y) is controlled by the threshold controller 11A so that edge intensity G (x, y) is large, and threshold E (x, y) becomes small.

[0124]Such threshold control is realizable as follows. For example, first, using the positive coefficient r (r<=1.0) set up beforehand, by the following (31) types, temporary threshold Etmp (x, y) to which the value becomes large is set up, so that the pixel value I of an inputted image (x, y) is large.

[0125]

[Equation 31]

$$Etmp(x, y) = rI(x, y) \quad \cdots (31)$$

[0126]Then, threshold E (x, y) which corrects this threshold Etmp (x, y) by edge intensity G (x, y), and actually uses it is determined. For example, the coefficient [constants / Emin and Emax / for the normalization in (8) types / types / (8)] G according to edge intensity (x, y) is computed as 0.0 and 1.0, respectively. This is integrated to temporary threshold Etmp (x, y) like the following (32) types, and it asks for final threshold E (x, y). By this, the value becomes large so that the pixel value I of an inputted image (x, y) is large, and threshold E (x, y) is controlled so that edge intensity G (x, y) is large, and the value becomes small.

[0127]

[Equation 32]

$$E(x, y) = Etmp(x, y)G(x, y) \quad \cdots (32)$$

[0128]Although the spatial change of an input pixel bears the role which separates what is depended on change of a lighting ingredient, and the thing to depend on change of the reflectance of an object surface, threshold E (x, y) of the epsilon delta technique filter 12, If the illumination level itself is large even when change of the reflectance of an object surface is small, change of the pixel value I (x, y) will become large. That is, how a big change of an illumination level and change of the small reflectance under powerful lighting are distinguished poses a problem. He is trying to set up greatly threshold E (x, y) of the epsilon delta technique filter 12 in this embodiment so that a pixel level is large, but the influence of the illumination level in change of the pixel value I (x, y) can be reduced by this, and it becomes possible to extract a lighting ingredient more appropriately.

[0129]Since it was made to control threshold E (x, y) of the epsilon delta technique filter 12 in consideration of the pixel level of not only edge intensity G (x, y) but an inputted image according to this embodiment as explained above, In the epsilon delta technique filter 12, it becomes possible to extract a lighting ingredient more

appropriately.

[0130][A 4th embodiment] Next, a 4th embodiment of this invention is described. In the following explanation, the same numerals are given to a portion which has the substantially same function as the above 1st - a component in a 3rd embodiment, and explanation is omitted suitably.

[0131]Drawing 15 shows composition of an image processing device concerning a 4th embodiment of this invention. Although composition of an image processing device concerning this embodiment is almost the same as a 3rd embodiment (drawing 14) of the above, It differs from a 3rd embodiment of the above in that it was made to perform threshold control of an epsilon delta technique filter especially using two kinds of thresholds Elo(x, y) Eup (x, y) for every pixel.

[0132]In the threshold controller 11B in this embodiment, two kinds of thresholds Elo(x, y) Eup (x, y) from which a size differs for every pixel are computed, and they perform threshold control of the epsilon delta technique filter 12A. Namely, like the following (33) types (33A) ((33B)) using the two coefficients rl and ru (0.0 <=rl, ru<=1.0) from which a size set up beforehand differs in the threshold controller 11B, for example, Two kinds of temporary threshold Etmplo(es) (x, y) and Etmpup (x, y) are computed. And they are outputted to the epsilon delta technique filter 12A as the 1st threshold Elo (x, y) and 2nd Eup (x, y).

[0133]

[Equation 33]

$$Etmplo(x, y) = rl \times I(x, y) \quad \cdots (33A)$$
$$Etmpup(x, y) = ru \times I(x, y) \quad \cdots (33B)$$

[0134]In the epsilon delta technique filter 12A in this embodiment, the two thresholds Elo(x, y) Eup (x, y) computed with the threshold controller 11B perform threshold processing. Processing with the epsilon delta technique filter 12A is performed as follows in more detail by the composition shown in drawing 16, for example. difference -- the difference value D (x, y) computed with the vessel 20 is sent also to the code judging machine 24 besides the absolute value calculation machine 21 in this embodiment.

[0135]In the code judging machine 24, the numerals of the difference value D (x, y) are judged, and the result is sent to the switch 27.

[0136]In the 1st comparator 25, a signal is chosen by (12) types like a 1st embodiment using the 1st threshold Elo (x, y) sent from the threshold controller 11B. That is, value AD (dx, dy) and the threshold Elo (x, y) which were computed with the absolute value calculation machine 21 are compared, either one of the value I of a noticed picture element (x, y) or the value I of a neighborhood picture element (x+dx, y+dy) is chosen according to the result, and it is outputted as the value J (dx, dy).

[0137]In the 2nd comparator 26, a signal is chosen by (12) types like a 1st embodiment

using the 2nd threshold Eup (x, y) sent from the threshold controller 11B. That is, value AD (dx, dy) and the threshold Eup (x, y) which were computed with the absolute value calculation machine 21 are compared, either one of the value I of a noticed picture element (x, y) or the value I of a neighborhood picture element (x+dx, y+dy) is chosen according to the result, and it is outputted as the value J (dx, dy).

[0138]In the switch 27, based on a decision result of the code judging machine 24, either of the outputs of the 1st comparator 25 or the 2nd comparator 26 is chosen, and it sends to the linearity low pass filter 23. In the switch 27, when it is shown for example, that a code judging result is positive, an output of the 1st comparator 25 is chosen. On the contrary, when a decision result is negative, an output of the 2nd comparator 26 is chosen.

[0139]According to this embodiment, when the value I of a neighborhood picture element (x+dx, y+dy) is larger than the value (value of a center of the neighborhood field NB) (x, y) I which is the present noticed picture element, the threshold Eup (x, y) is used, and when small, Elo (x, y) is used. That is, in the epsilon delta technique filter 12A, it is possible to set up a threshold which is different by the high-level and low side. In particular, the 2nd threshold Eup (x, y) can reduce influence of a lighting ingredient contained in change of a pixel value like a 3rd embodiment by making it become larger than the 1st threshold Elo (x, y), and it becomes possible to extract a lighting ingredient more appropriately.

[0140][A 5th embodiment] Next, a 5th embodiment of this invention is described. In the following explanation, the same numerals are given to a portion which has the substantially same function as the above 1st - a component in a 4th embodiment, and explanation is omitted suitably.

[0141]Drawing 17 shows composition of an image processing device concerning a 5th embodiment of this invention. Although composition of an image processing device concerning this embodiment is similar with a 1st embodiment (drawing 1) of the above, it differs in that it was made to perform nonlinear conversion of logarithmic transformation etc. to a pixel level of an inputted image first especially.

[0142]That is, in this embodiment, the logarithmic converter 17 is installed in an input stage of a circuit, and logarithmic transformation first shown in (1) type to each pixel value I of an inputted image (x, y) is performed. The multiplier 15 for the divider 13 for deducting the lighting ingredient R (x, y) obtained with the epsilon delta technique filter 12 in connection with this to integrate lighting ingredient CR (x, y) compressed into the subtractor 18 for the non-illuminating ingredient S (x, y) is transposed to the adding machine 19. These are based on a fact known well of becoming addition and subtraction, in after addition and division log transforming.

[0143]Pixel value IL (x, y) of an inputted image after being log transformed by the logarithmic converter 17 is sent to the edge intensity calculation machine 10, the epsilon delta technique filter 12, and the subtractor 18. In the edge intensity calculation machine

10 and the epsilon delta technique filter 12, the same processing as a 1st embodiment of the above is performed based on the pixel value IL (x, y). On the other hand, in the subtractor 18, by subtracting from each pixel value IL (x, y) the lighting ingredient R (x, y) obtained with the epsilon delta technique filter 12, a lighting ingredient is removed from an inputted image and the non-illuminating ingredient S (x, y) obtained as a result is outputted to the adding machine 19. In the adding machine 19, a picture signal is restored by adding amendment lighting ingredient CR (x, y) to the non-illuminating ingredient S (x, y), and it outputs to a transmission line, memory storage, or a display etc. which does not illustrate the picture signal O of the result (x, y) like a 1st embodiment of the above.
[0144]Itself has a compression effect of a dynamic range, and as for logarithmic transformation used by this embodiment, the pixel value I (x, y) is greatly compressed, so that an input level is high. Thereby, substantially like 3rd and 4th embodiments of the above, influence of an illumination level in a spatial change of a pixel value will be reduced, and it becomes possible to extract a lighting ingredient more appropriately.
[0145]Although this embodiment explained an example which log transforms as nonlinear conversion, it may be made to perform other nonlinear conversion other than logarithmic transformation.
[0146]
[Effect of the Invention]As explained above, according to the image processing device given in an image processing method given in any 1 paragraph of claims 1 thru/or 8, or any 1 paragraph of claims 9 thru/or 16. Based on the edge intensity computed for every position on an inputted image, control the threshold used with an epsilon delta technique filter, and. According to the output value from the epsilon delta technique filter by which the threshold was controlled, compute the coefficient for changing a pixel value, and with the computed coefficient, since it was made to change the pixel value for every pixel, Also when several different lighting exists, it becomes possible to extract those boundaries appropriately, generating of an unnatural image pattern is suppressed, and compression of a desirable dynamic range can be realized subjectively.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is a block diagram showing the composition of the image processing device concerning a 1st embodiment of this invention.
[Drawing 2]It is an explanatory view showing the scanning direction of a picture.
[Drawing 3]It is an explanatory view showing the example of a level conversion function.

[Drawing 4]It is a block diagram showing the composition of the epsilon delta technique filter in the image processing device shown in drawing 1.
[Drawing 5]It is an explanatory view showing the difference from the reappearance picture by the image processing device shown in the reappearance picture and drawing 1 by a conventional method.
[Drawing 6]It is an explanatory view showing the relation between a level conversion function and a coefficient enumeration function.
[Drawing 7]It is an explanatory view showing the effect of an epsilon delta technique filter.
[Drawing 8]It is an explanatory view showing the behavior in the edge circumference of the epsilon delta technique filter of threshold immobilization.
[Drawing 9]It is an explanatory view showing the reversal phenomenon of the level inclination produced in the epsilon delta technique filter of threshold immobilization.
[Drawing 10]It is an explanatory view showing the relation between the level conversion function used for the output of an epsilon delta technique filter, and its differential value.
[Drawing 11]It is an explanatory view showing the size function of an input level and a compression ratio in a level conversion curve.
[Drawing 12]It is a block diagram showing the composition of the image processing device concerning a 2nd embodiment of this invention.
[Drawing 13]It is an explanatory view showing the example of the coefficient enumeration function used in the coefficient calculation machine in the image processing device shown in drawing 12.
[Drawing 14]It is a block diagram showing the composition of the image processing device concerning a 3rd embodiment of this invention.
[Drawing 15]It is a block diagram showing the composition of the image processing device concerning a 4th embodiment of this invention.
[Drawing 16]It is an explanatory view showing the composition of the epsilon delta technique filter in the image processing device shown in drawing 15.
[Drawing 17]It is a block diagram showing the composition of the image processing device concerning a 5th embodiment of this invention.
[Drawing 18]It is an explanatory view showing the example of the level conversion function used conventionally.
[Drawing 19]It is an explanatory view showing the example of other level conversion functions used conventionally.
[Drawing 20]It is an explanatory view showing the principle of histogram IKORAIZESHON.
[Drawing 21]It is a figure for explaining the problem of the Multiscale retinex method.
[Description of Notations]
10 -- An edge intensity calculation machine, 11 -- A threshold controller, 12, 12A --

Epsilon delta technique filter, 13 -- a divider and 14 -- a level converter and 15 -- a multiplier and 16 -- a coefficient calculation machine and 17 -- a logarithmic converter, and 18 and 20 -- difference -- A vessel and 19 -- an adding machine and 21 -- an absolute value calculation machine, and 22, 25 and 26 -- a comparator and 23 -- a linearity low pass filter (LPF) and 24 -- a code judging machine and 27 -- a switch.